Fig. 2 is a view similar to Fig. 1 but showing a conventional high expansion ratio type of turbine wherein employment of the invention is of less consequence;

Fig. 3 is a sectional view of a reaction turbine stage;

Fig. 4 is a detail side elevational view of the structure shown in Fig. 3; and

Fig. 5 is a diagrammatic view showing the discovered relation of flow area ratio to stage efficiency and gauging, all for favorable stage velocity ratios.

Referring now to the drawing, Figs. 3 and 4 will first be considered to make clear certain geometric quantities of importance to the present invention. The following dimensions are indicated:

h=blade height
l=chord
o=minimum opening
s=pitch

From these quantities are derived dimensionless ratios including the aspect ratio, h/l, and gauging, o/s. The quantity or ratio $h/l \times o/s$ is referred to herein as the "flow area ratio."

The efficiency of a turbine stage is a function of many quantities, certain ones of which are geometric. The geometric quantities include the flow angles (α and β) which fix the actual velocity ratio, and the ratios h/l, s/l and o/s; and, of these, the ratios h/l and o/s are of particular interest to the present invention.

As hereinbefore pointed out, the persent invention rests on the discovery that, at favorable velocity ratios, the rate of change of efficiency with gauging increases as the flow area ratio, $h/l \times o/s$, diminishes. This means that the invention has greatest significance with constant velocity ratio turbines, such as high-pressure units of compound installations and topping turbines, where the aspect ratio is small, and, because of the low expansion or pressure ratio, it does not change so greatly from the inlet to the exhaust. With large steam density and high power ratings, the blade loading is high and the blade section measured by the chord, l, must be large enough to give the required strength. Increasing l for this purpose diminishes the aspect ratio, h/l, and also the flow area ratio. As shown in Fig. 5, I find that it becomes increasingly important, from the point of view of stage efficiency, to properly choose the gauging for the smaller flow area ratios. The blade height, h diminishes toward the high-pressure end, and, at the same time, for reasons of strength, as the high-pressure end is approached, the chord l of the blading must frequently be relatively wider than is the case with blading of comparable heights in turbines of greater expansion ratio, such as shown in Fig. 2. Thus, the aspect ratio may be diminished toward the high-pressure end by both of the factors h and l; and the gauging must be modified from the low-pressure end to the high-pressure end, as hereinafter explained in detail, to obtain the best stage efficiency.

In Fig. 1, there is shown a turbine of the low expansion, or pressure, ratio type supplied with steam or elastic fluid at high initial absolute pressure, for example, at pressures of the order of 900 or 1000 lbs./sq. in. and above. The exhaust or back pressure is high enough to keep the expansion ratio low. If, for example, with an initial pressure of 1000 lbs./sq. in., the exhaust or back pressure is 100 lbs./sq. in., then the expansion ratio is 10; and, if the back pressure is 500 lbs./sq. in. for the same initial pressure, the expansion ratio is 2. Comparing the turbine of Fig. 1 with one of the high expansion ratio type, such as shown in Fig. 2, if, with the latter, the initial pressure is 500 lbs./sq. in. and the exhaust pressure ½ lb./sq. in. absolute, it will be seen that the pressure ratio is very much higher, that is, 1000.

Referring again to Fig. 1, the turbine includes rotor and cylinder elements 10 and 11 and a plurality of reaction stages 12 each including a stationary row of blades 13 followed by a row of moving blades 14 carried by the rotor.

With reaction turbines, it has been the practice to adhere to a fixed gauging, o/s, for example, 30%, throughout the turbine. I find that this is detrimental to turbine efficiency in general, but particularly to the efficiency of high-pressure units designed for favorable velocity ratio and low expansion ratio. With constant gauging heretofore commonly employed with reaction turbines, the necessary increase in flow area from the high-pressure to the low-pressure end of the machine is provided only by increase in blade height. I provide for variation in gauging from end-to-end of the turbine, the gauging being smaller at the high-pressure end than at the low-pressure end. As the flow area of a blade row is fixed by the blade height and by the gauging, the decrease in gauging toward the high-pressure end gives somewhat greater blade heights than would otherwise be obtained. The important reason for varying the gauging is, for the required flow area ratio, to obtain the optimum efficiency, or nearly so. As the flow area ratio, $h/l \times o/s$, becomes smaller, the rate of change of efficiency with gauging becomes greater (Fig. 5).

From Fig. 5, it will be seen that, as the flow area ratio becomes greater, gauging variation has less and less effect on the efficiency until, at large flow area ratios, the efficiency is not substantially affected by gauging variation within wide limits. The curve a representing a flow area ratio of 1/2, referred to stage efficiency and gauging coordinates, has a relatively much larger change in slope than the curves b and c, indicating flow area ratios of 2/2 and 3/2. That is, as the flow area ratio becomes smaller, the rate of change of efficiency with gauging, for constant velocity ratios, increases. While the gauging of the blading may vary from row to row, I prefer to arrange the blading in groups, 16, 17, 18 and 19 in Fig. 1, with the gauging of the blading of each held the same but decreasing group by group from the low-pressure to the high-pressure end.

While the invention has been shown in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof, and it is desired, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What is claimed is:

1. In a full-peripheral admission reaction turbine designed for a relatively small expansion ratio and a narrow range of stage velocity ratios, a plurality of successive stages, each stage including a pair of rows of relatively movable blades; the blades having a height dimension h and a chord dimension l sufficiently large in relation to height to give an aspect ratio, h/l, of the order of four as a maximum at the low-pressure end and decreasing therefrom toward the high-pressure end of the turbine because of decrease in